RESEARCH INTERNSHIPS IN SCIENCE AND ENGINEERING (RISE): LESSONS FROM THE FIRST YEAR

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Abstract *— Based on the literature on barriers to women's success in science, technology, engineering, and mathematics (STEM), an innovative educational intervention has been developed at the University of Maryland. In the second year of implementation, Research Internships in Science and Engineering (RISE) is designed to facilitate mentoring and role modeling for women at all levels of higher education: from incoming first year students, advanced undergraduates, and graduate students, to female faculty members. RISE is a two tiered program consisting of The First Year Summer Experience (FYSE) focusing on incoming first year students and Summer Research Teams concentrating on upper-level undergraduates, graduate students and faculty. Evidence from the first year of implementation will be provided to show how this program uniquely addresses several of the major barriers that women face in STEM fields.*

Index Terms — Barriers, Mentor Hierarchy, Research Program, Retention Strategy

RESEARCH INTERNSHIPS IN SCIENCE AND ENGINEERING (RISE): PROGRAM DESCRIPTION

There are two key points in the education of undergraduate women where participation in a deliberately designed intervention can significantly impact their success: first, during the transition from high school to college (which tends to be the initial encounter with the male dominated STEM environment) and second, during the latter half of their undergraduate education, when career options, including whether or not to pursue graduate education, are being considered. The RISE program takes advantage of both of these educational opportunity points. Track One, the First Year Summer Experience is designed for incoming first year students whereas Track Two, the Summer Research Teams was created for advanced undergraduates (primarily juniors and seniors).

RISE: The First Year Summer Experience (FYSE) is a two week residential orientation program for first year female students entering engineering, mathematics, computer science or physical science at the University of Maryland (UM). The focus is on addressing issues of self-confidence and maximizing the chances that students will be successful during their initial year. Based on previous research indicating that female students often enter STEM fields with fewer technical skills, less computer expertise, and/or less confidence than their male counterparts, the FYSE includes technical survival skill sessions [11]. Activities incorporate learning basic computer skills (including the hands-on experience of taking apart and rebuilding a computer), and learning how to use the electronic communication services at UM. Faculty mentors provided orientations to their laboratories and research projects. Participants, the faculty mentors, parents, and selected campus guests are invited to a concluding luncheon where the students give group presentations of what the RISE experience meant to them. Participants who successfully completed the program received a $500 scholarship and a certificate of accomplishment. In the first year of the project, twenty-four students completed the program and received the scholarship.

RISE: Summer Research Teams (Track Two) involves a guided research team experience for junior and senior women majoring in engineering or the sciences. While positive team experiences have been shown to motivate students and encourage higher levels of academic achievement leading to increased retention and graduation, a common experience for women on undergraduate project teams involves being in the minority [2], [3], [8], [13]. As a result, the team experience may become yet *another challenge* for the female student dealing with isolation, rather than being a source of peer support and learning.

The goal of the Track Two program is to encourage women to remain committed to their STEM major, become excited about research, and increase their network of female contacts in engineering and the sciences. The core experience for Track Two participants is involvement in a team of peers with the benefit of female role models and faculty mentor that create a positive and supportive "micro-climate." In the first year of the program, there were five research teams involving a total of eighteen undergraduates. In addition, participants attended workshops on effective

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mentoring and advanced team skills training. The concluding event of the Track Two program is a *Research Symposium.* At this event, the research teams presented the results of their work to RISE Track One students, their parents, and invited individuals from the campus. In the first year of our program, the keynote speaker was Dr. Rita Colwell, Director of the National Science Foundation, who spoke about the future of science and technology, emphasizing key individuals who made a difference in STEM.

How STEM Barriers are Addressed

Both tracks of the RISE program were rigorously assessed during the first year of implementation. Undergraduates completed written surveys, and participated in focus groups and interviews. The perspectives of faculty mentors, graduate fellows, and undergraduate fellows were evaluated using semi-structured interviews. Three key issues related to increasing the persistence of women in STEM fields along with programmatic implications for the future of RISE emerged from the data analysis: a lack of critical mass and chilly climate, lack of role models and lack of belief in one's self. Each is discussed below.

Barrier 1: Lack of Critical Mass and Chilly Climate

As previously noted, the number of women involved in STEM fields is far less than their presence in the U.S. population. Colleges of engineering averaged approximately 20% undergraduate females [6]. However the percentages shrink dramatically when reviewing female graduate student and faculty numbers. The shortage of women in STEM has been termed a "lack of critical mass," based on the scientific notion that a certain percentage or threshold is necessary before change can occur. The chilly or unwelcoming climate is one of the frequently cited reasons that women do not persist in STEM fields to reach critical mass levels. The history of women in science abounds with examples of overt and covert discrimination [12]. We attempted to deal with these issues in the RISE program by creating a positive and supportive micro-climate where women were in the *majority.* Because the participants were teamed with all females and the emphasis was on succeeding in STEM, both the lack of critical mass in STEM fields as well as "chilly climate" issues in the environment were addressed.

How well did the RISE program succeed in compensating for the lack of critical mass and chilly climate experienced by women in STEM? Based on the qualitative data from interviews (N=10) and focus groups (N=5 teams) with students conducted at the end of the first year, our achievement with regard to this issue was mixed. According to the students, we were most successful in overcoming critical mass issues. Participants reported enjoying the all female experience: taking part in genuine research projects and the comfort they perceived within the female team environment. Several noted that RISE provided them with their first educational experience with a female professor. Additionally, networking was noted as a positive outcome from the RISE experience. Because almost two thirds of the Track Two students came from other campuses than UM, the participants were able to create a true nationwide network of friends and future colleagues.

One of the most intriguing findings of our assessment was the *lack of impact* on attitudes toward "chilly climate" issues. While commonly perceived and discussed by those responsible for the success of young women coming into these fields, we found the undergraduate participants (first year and upper-level students) resistant to the idea that there were *any* barriers that might impact their success. RISE participants complained that the gender gap was over-emphasized and no longer relevant to their generation. Most of these comments were in reference to training sessions we held related to women in science, leadership, and self confidence. Some of our students felt it would have been more helpful to have learned how to be successful in STEM fields, regardless of gender.

Assessment interviews conducted with the graduate students who acted as role models and mentors on the research teams told a slightly different story. One student detailed her negative experiences as a woman in STEM and the difficulties she observed occurring to her female academic advisor and RISE faculty mentor. She suggested that undergraduates are *not* likely to be as isolated as graduate students and may therefore underestimate the impact of chilly climate concerns. Graduate students who were from other countries noted that the support for women earning advanced degrees was *worse in the US* compared to what they were used to in their native countries (i.e., Taiwan, Bulgaria).

As a result of these assessments, several changes will be implemented in the RISE program. We will modify our language and address the chilly climate differently. Without labeling them as "women issues" during training sessions, we will address what our experience and the research on women's success in STEM fields suggests. For example, we will continue to provide training in conflict management, but bring in female engineers and scientists to describe how they deal with conflict in real life situations. Rather than describing women's styles of handing conflict abstractly, we will add a role model component and provide concrete examples of how women successfully handle predictable work difficulties. A second change in this arena will be the addition of a book club. After reading a biography of a woman scientist (e.g., *Rosalind Franklin and DNA***,** by Anne Sayre[12]) or a book of fiction that describes women working in a technical environment (e.g., *Engineered for Murder,* by Aileen Schumacher)[15], undergraduate participants will have a discussion with their mentors. Through the use of literature, we hope to tease out the issues related to women in science in a more subtle manner.

Barrier 2: Lack of Role-Models

In STEM fields, female students often view female faculty members as role models and potential mentors. Role models are examples of students' aspirations. They demonstrate how to succeed in a context or environment in which students envision themselves in the future. Because of the paucity of women in STEM environments, female undergraduates often lack role models and mentors—especially women. Research on effective role modeling suggests that the greater the perceived similarity, the greater the impact of the role model [1], [5]. In the design of RISE, we took advantage of this social psychological finding by providing a "hierarchy of role models" for our undergraduate participants. Specifically, each research team consists of the following chain of influence:

- The *RISE Undergraduate Fellow:* A student who is also a peer, yet has some prior experience with the faculty mentor's research project (the degree of similarity is greatest with the Undergraduate Fellow).
- The *RISE Graduate Fellow:* A more advanced role model committed to science and engineering by virtue of seeking an advanced degree.
- The *Faculty Mentor:* Completes the team and while a role model, goes beyond this to mentorship. Different than role models, mentors actively engage in their protégés' lives, encourage their occupational success, and advise them on various areas of personal and professional concern [9].

Our qualitative assessment suggests that the role model hierarchy approach to team structure was of significant value to *both* the undergraduate and graduate students. Undergraduates expressed admiration and a willingness to engage with the graduate students to a greater degree than the faculty. Indeed, in some cases the graduate students had significant responsibility for the teams at various points in the summer experience and were viewed as more available than faculty. Our data showed that the effectiveness of the Undergraduate Fellow was determined by the degree of expertise demonstrated by that individual with regard to the research project. In one case where the Fellow did not have much prior experience with the project, the participants questioned her role on the team and the extra salary she earned.

While the original intention of the RISE program is to encourage *undergraduate* women to persist in STEM fields, we were surprised during our assessment to find the degree of impact upon the graduate students. In all cases, they reported that they *loved* working with the undergraduate RISE students. Most had originally agreed to participate because their faculty advisor had asked them or they appreciated the extra funding this opportunity provided, they ended up being delighted with the program and their role within it. They took their responsibilities as role models seriously and gave the undergraduates advice about applying for graduate school and internships. One graduate student felt she had moved from the "bottom of the pile" in terms of her status as a graduate student, to an esteemed position in the eyes of the undergraduate team members. Others reported a renewed enthusiasm about their decision to become academics by teaching and helping students realize the joy of discovering new knowledge. For these students, discussions of critical mass and chilly climate reflected their personal experiences in STEM. Conversations about these topics were a revelation: one graduate student said that RISE provided her the opportunity to talk about these issues with her female faculty mentor and to deepen their relationship.

In terms of programmatic implications from our evaluation of the first year, the results reinforce the need to encourage faculty to find female graduate students to work as a part of the research teams, for their significant impact on the undergraduates and the support the program offers the women graduate students. The difficulty with having *only* females in the graduate student fellow role is the lack of available candidates.

Furthermore, in training sessions during the next year of the program, we will *increase the emphasis* of the role of the graduate student in the role model hierarchy. We will specifically identify the benefits of participation to the graduate students themselves. Finally, our future assessments will explore further the impact on graduate students' commitment to STEM fields and involvement with undergraduate education.

Barrier 3: Lack of Belief in One's Self

In their new book, "Unlocking the Clubhouse: Women in Computing" [11], Margolis and Fisher discussed the profound impact of female student's failure to believe in themselves at critical junctures in the STEM undergraduate curriculum. These authors noted a "self confidence gap" that adversely affects women interested in the sciences and engineering. Often comparing themselves with men, young women *evaluated their interest in STEM fields as less, because their familiarity was less.* Especially in computer science and engineering fields, men tended to enter college with more "hands-on experiences." For example, many men reported having taken apart computers and working in the garage putting together mechanical and electronic devices. Because female students may lack these experiences, they may feel "behind" at the start of their college educations. Furthermore, the authors noted that males and females often differ in how they judge poor performance: women tend to see the cause of the failure as internal, relating to the self (e.g., not good enough) whereas men find external reasons (e.g., a hard and unfair test). These factors and others already mentioned (e.g., lack of critical mass and chilly climate) combine to create a situation where young women do not feel confident or capable of succeeding in STEM fields.

While one could argue that the entire RISE program is an effort to promote the abilities and commitment to STEM, specific interventions were designed to positively impact self confidence with regard to performance in STEM fields. With the Track One program, participants were exposed to hands-on activities including a computer tear down. They were invited into the labs of the Track Two participants and exposed to the research projects being conducted by women just a few years older than them. They visited professional research environments such as NASA and NIST. Both levels of the program were imbued with role models so that students could see women enjoying and succeeding in science. Track Two students participated in discussions about women in science and increased their skills in problem solving, analysis, and experimentation through working side by side on a research project in a virtually all female team environment.

The impact of the RISE program on student self confidence and commitment to STEM was evaluated both qualitatively through interviews and quantitatively through a paper/pencil assessment of self-efficacy completed at the end of the summer program. Lent [10] defines self-efficacy as a sense of ability that one can complete an action or activity. In the case of engineering and the sciences, we are interested in determining if the RISE program has an impact on participants' self- efficacy with regard to engineering and mathematics (a necessary pre-requisite for success in all STEM fields). Measures of self-efficacy were given to Track Two students at the beginning and end of the program, while Track One students will complete their post-test at the end of the first academic year. Due to this schedule of assessment activities, we do not have quantitative results of self-efficacy changes to report at this time. However, from our focus group and interviews, we do have qualitative observations to share.

Beginning with Track One, all of our first year participants reported significant gains in their comfort with the university environment, particularly making new friends with whom they will share classes in the fall. Many of their comments related to the increased sense of confidence gained in their ability to be successful college students. Increased familiarity with the campus, its resources, the local area, even the buildings where their classes will be held, all were identified as key aspects of a positive transition to college. Students wished that they had *more opportunities* to engage in hands on engineering and science experimentation (similar to the computer tear down project). In addition, many of these incoming first year students reported wanting more information on college majors to reinforce their initial choices.

Track Two students increased their self confidence regarding their abilities to do research in engineering and the sciences (including specific tasks pertinent to their individual projects). They also reported enjoying acting as role models to the incoming first year students. Other comments included the following: 1) appreciating the benefits of participating in a primarily female team where there were no slackers (in other words, all team members materially contributed to the research project) and no Type-A dominating personalities; 2) being independent; 3) gaining insight into their own strengths and weaknesses; and 4) meeting other women who were “intelligent and motivated.”

Based on the qualitative evidence collected at the time of the program, we believe the self confidence and efficacy to be successful in STEM was vastly improved for RISE participants. We expect these findings to be confirmed with quantitative measurement (using the Lent measure of self-efficacy) and future follow-up discussions planned with both Track One and Track Two participants. In addition, assessments will include evaluating outcomes such as commitment to STEM fields (by tracking academic performance and persistence in STEM majors), graduation and continued interest in a STEM career and/or desire to attend graduate school, as well as positive perceptions about women in science and engineering fields.

CONCLUSION

The data reported here offers empirical support that RISE increases the confidence (and we hope, eventual persistence) of undergraduate women in STEM fields. In addition, the RISE program has the potential to bring some of the advantages of an all-female learning environment, epitomized by women’s colleges, into more mainstream higher education. Using role model hierarchies to compensate for the lack of critical mass and chilly climate, hands-on activities such as computer tear downs and involvement in female research teams to build self efficacy, RISE contains *replicable features* that can be adopted by a variety of institutions seeking to maximize the participation and success of female students in STEM fields. Assisting the bright and ambitious young women who enter higher education in science, technology, engineering and mathematics majors overcome the barriers addressed here, not only enhances their personal and professional success but impacts the nation as a whole. The two track RISE program strives to "even the playing field" so that all those who have the will and the talent can contribute to an improved technological world. Future reports will focus on the longitudinal impact of the RISE program on persistence and satisfaction with STEM fields.

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